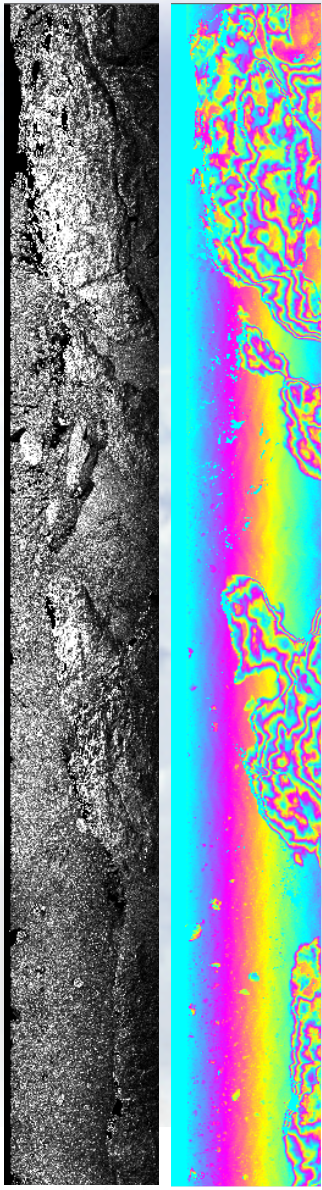


The Airborne Glacier and Ice Surface Topography Interferometer (GLISTIN-A)

Delwyn Moller (PI)
James Carswell, Gregory Sadowy
Scott Hensley, Charles Fisher, Yunling Lou,

Acknowledgements: Xiaoqing Wu, Jim Canniff, Maurio Grando, Lance Milligan, Hung Pham

6/20/2011

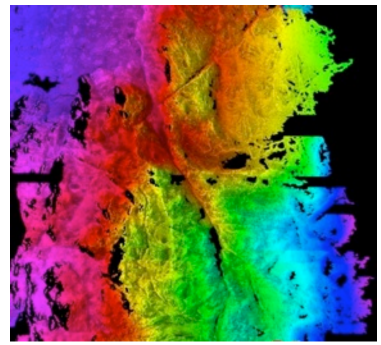
The Airborne Glacier and Land Ice Surface Topography Interferometer (GLISTIN-A)

PI: Delwyn Moller, Remote Sensing Solutions (RSS)

Objective

- Provide an ice surface topography, swath mapping sensor capable of operationally supporting NASA cryospheric science campaigns including potential IceBridge participation and ICESat-II augmentation - especially in coastal regions.
- Transition the Ka-band interferometer capability developed under the NASA International Polar Year (IPY) to a permanently available Ka-band UAVSAR configuration
- Improve IPY configuration to provide enhanced performance (e.g. ping-pong) and swath-mapping capability.
- Enable compact "plug and play" reconfiguration between L-band UAVSAR and Ka-band.

Ka-band antennas on the NASA GIII for single-pass interferometry



Left: example height map over Greenland's coast collected 5/1/2009. Color wrap is 800m and swath is 7.5km. GLISTIN-A will improve swath coverage to >10km.

Approach

- Upgrade front-end-electronics for ping-pong operation
- Integrate a state-of-the-art solid-state-power-amplifier (SSPA) to contain all GLISTIN-A hardware on the panel assembly.
- Perform thermal analysis and modify the panel to accommodate the new hardware
- Verify upgrades with engineering checkout and calibration flights on the Gulfstream III
- Update the Ka-Band single-pass processor for the GLISTIN-A configuration including ping-pong mode

Key Milestones

• Complete transceiver design	11/10
• Compete thermal analysis	07/11
• Complete transceiver integration & test	01/12
• Complete Ka-Band pod integration & test	03/12
• Flight Readiness Review	04/12
• Complete calibration/Engineering flights	06/12
• Calibrated Data/Digital Elevation Models	09/12

Co-Is/Partners

James Carswell, RSS; Scott Hensley, Gregory Sadowy, Yunling Lou, Charles Fisher, Jet Propulsion Laboratory

Outline

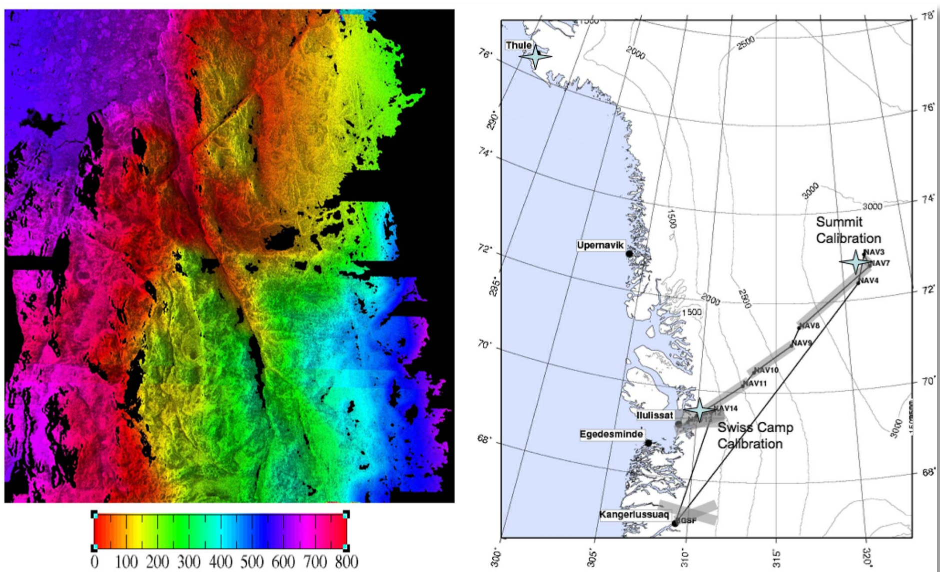
- Summary of GLISTIN-A International Polar Year progress and findings
  - System performance/stability
- AITT system upgrades
  - performance implications
  - Block diagram and key design criteria
- Ka-band RF electronics accommodation
- Timeline
- Technology infusion and Related NASA and NASA ESTO programs

IEEE TRANSACTIONS ON

GEOSCIENCE AND REMOTE SENSING

A PUBLICATION OF THE IEEE GEOSCIENCE AND REMOTE SENSING SOCIETY

FEBRUARY 2011 VOLUME 49 NUMBER 2 IGRSD2 (ISSN 0196-2892)



The image shows the topography over the West Coast of Greenland generated from a Ka-band single-pass interferometric radar flown on the NASA GIII as part of the NASA International Polar Year activities in May 2009.

IEEE

GLISTIN IPY update

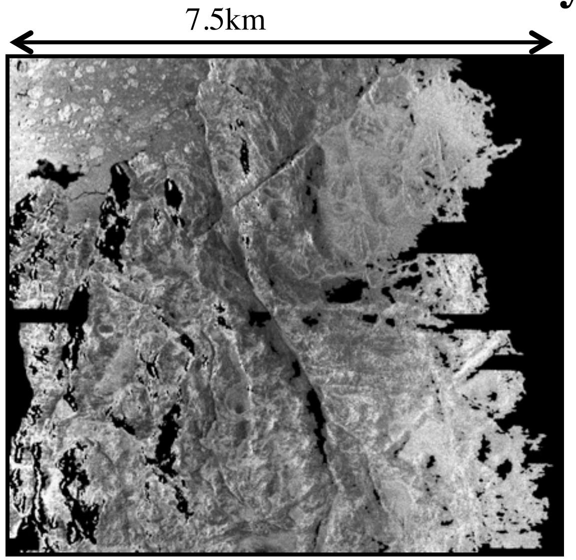
- System paper published (on the cover!)
- System performance as predicted
- Detailed processing nearly complete
- Science and analysis papers to follow!

Moller, D.; Hensley, S.; Sadowy, G. A.; Fisher, C. D.; Michel, T.; Zawadzki, M.; Rignot, E.; , "The Glacier and Land Ice Surface Topography Interferometer: An Airborne Proof-of-Concept Demonstration of High-Precision Ka-Band Single-Pass Elevation Mapping," IEEE Trans. Geoscience and Remote Sensing, vol 49., PP 827-842, Feb. 2011 doi: 10.1109/TGRS.2010.2057254

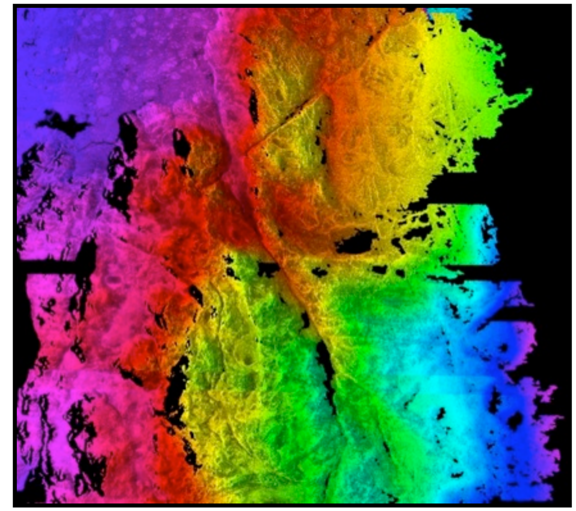
Requirement	
Coverage	>5km (10km goal)
Coastal Accuracy	50cm
Coastal Posting	30m x 30m
Ice Sheet Accuracy	10cm
Ice Sheet Posting	100m x 100m

IPY Performance Summary

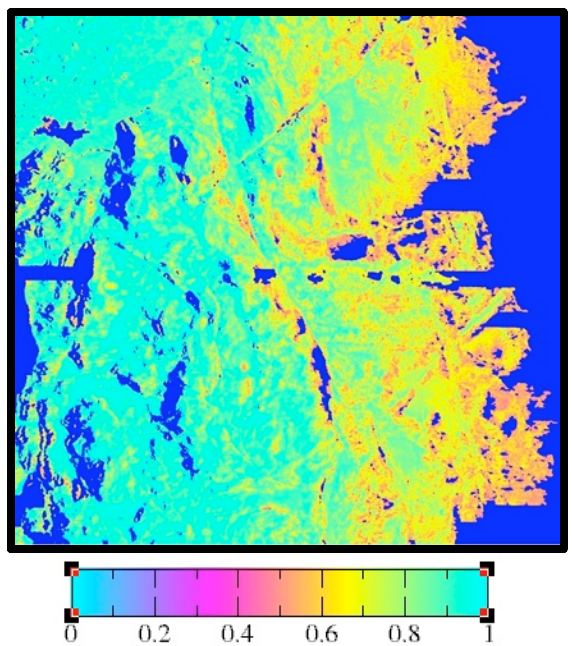
Parameter	Value
Date Collected	3/01/2009
Location	69.1° , -49.7°
Map Posting	3 m
Platform Altitude	8000 m
Mapped Swath	7500
Number Looks	30



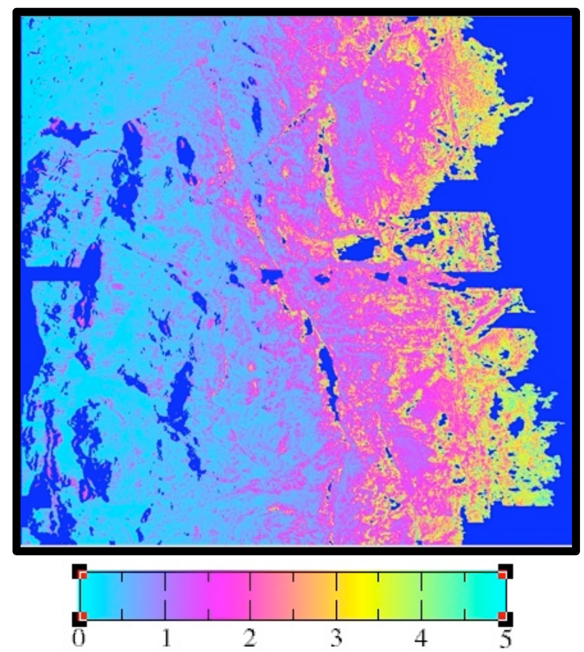
Relative Backscatter Image



Height Map: 800m color wrap



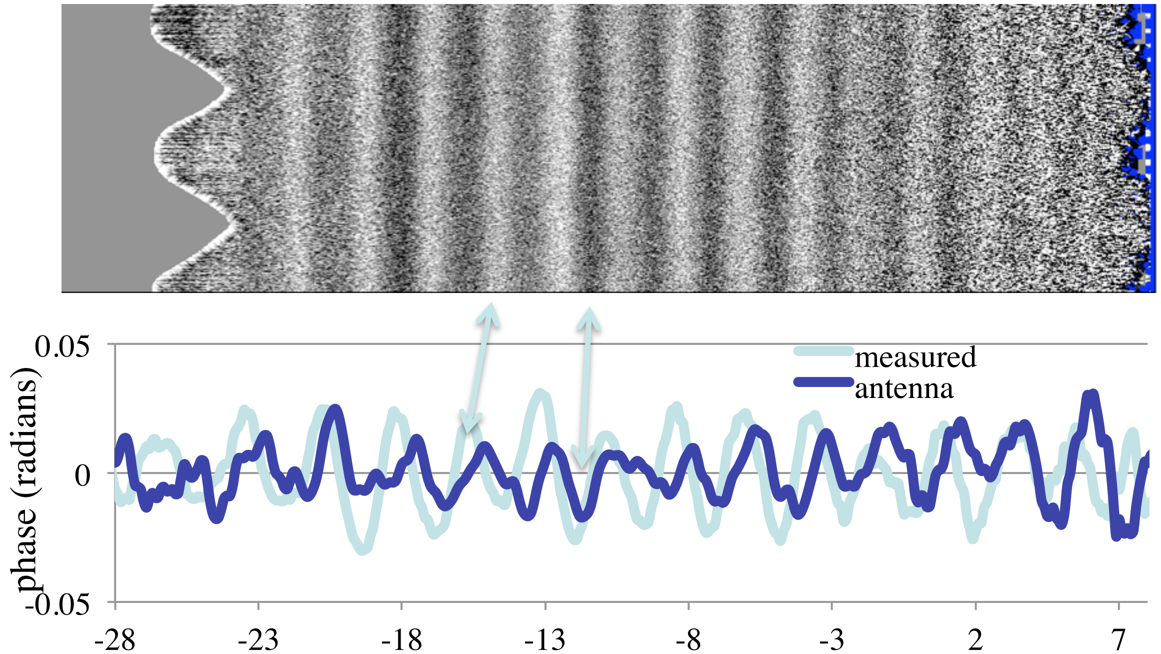
Correlation

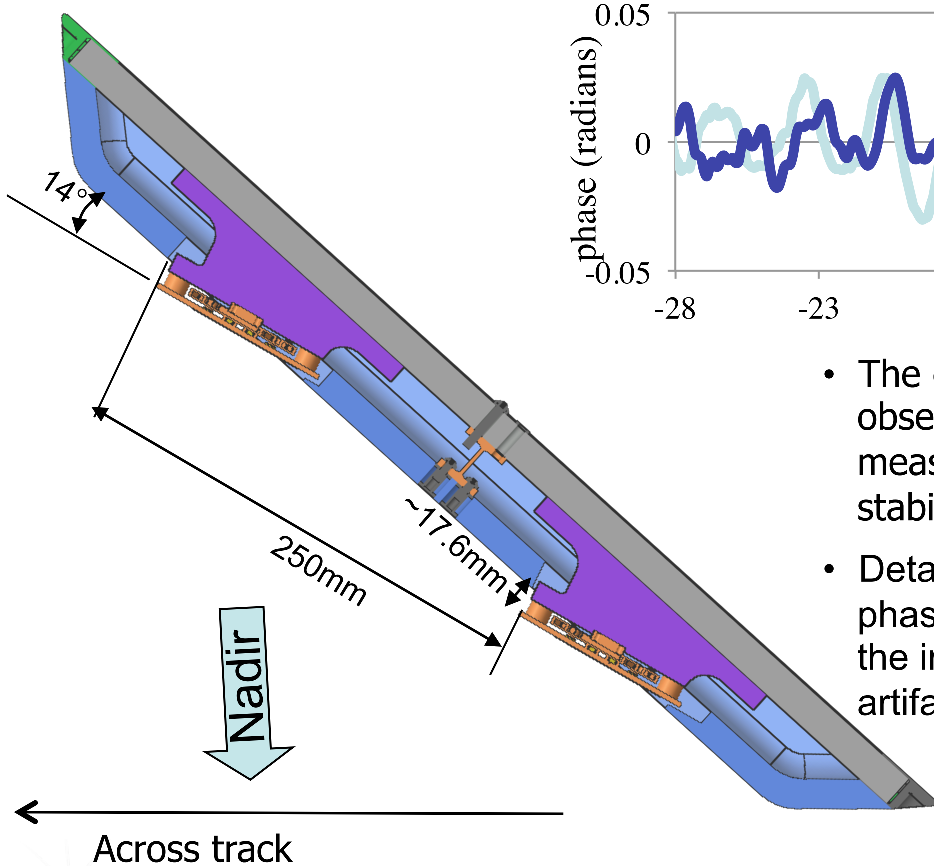


Height Precision Map (m)

Height precision ranges from 30cm near-range to 3m far-range for 3m horizontal posting. Therefore this is compatible with the science accuracy requirements in terms of system precision. (e.g. 3cm-30cm precision for 30m horizontal posting).

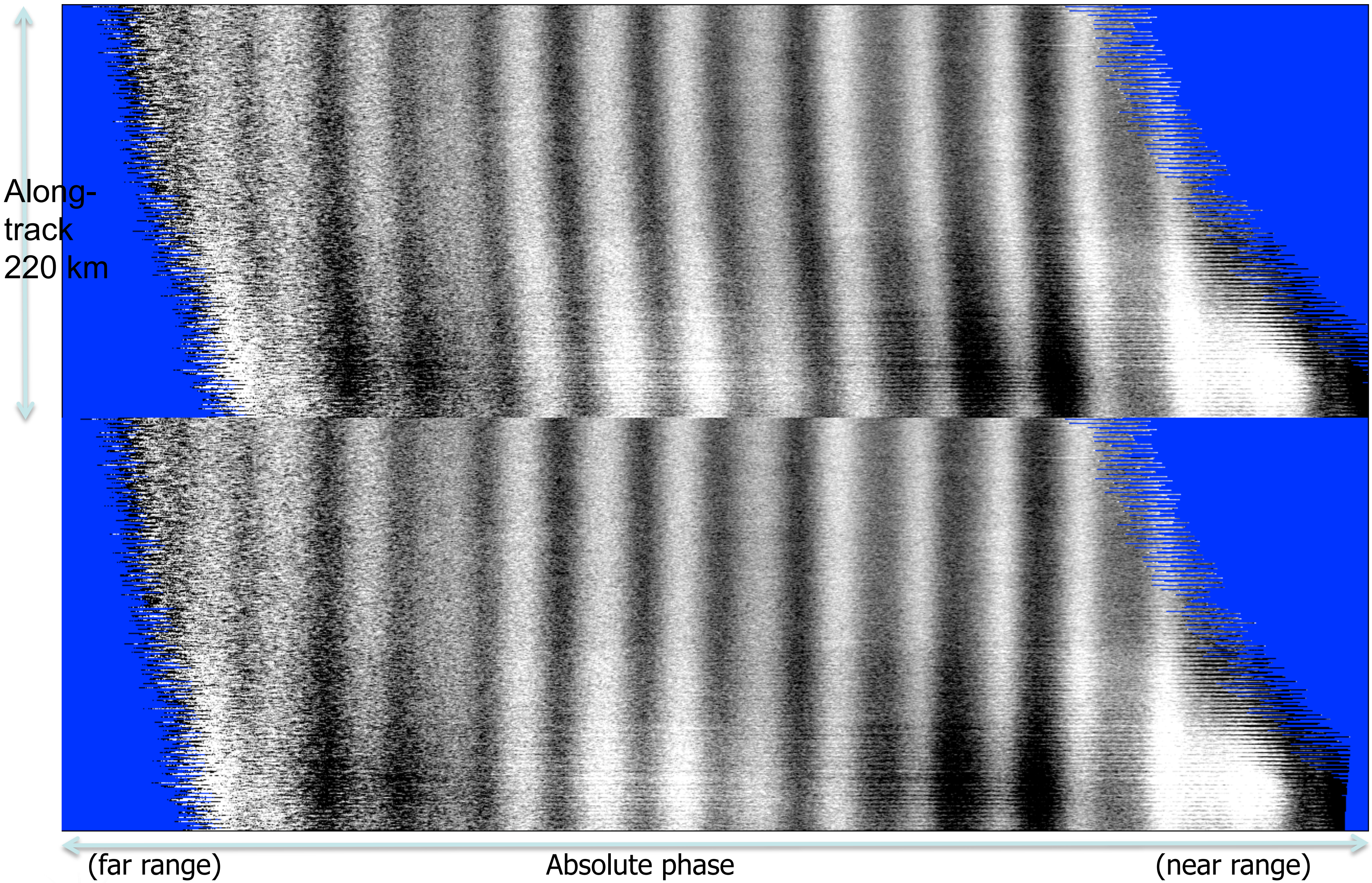
IPY Observations: Processing and Systematic Errors



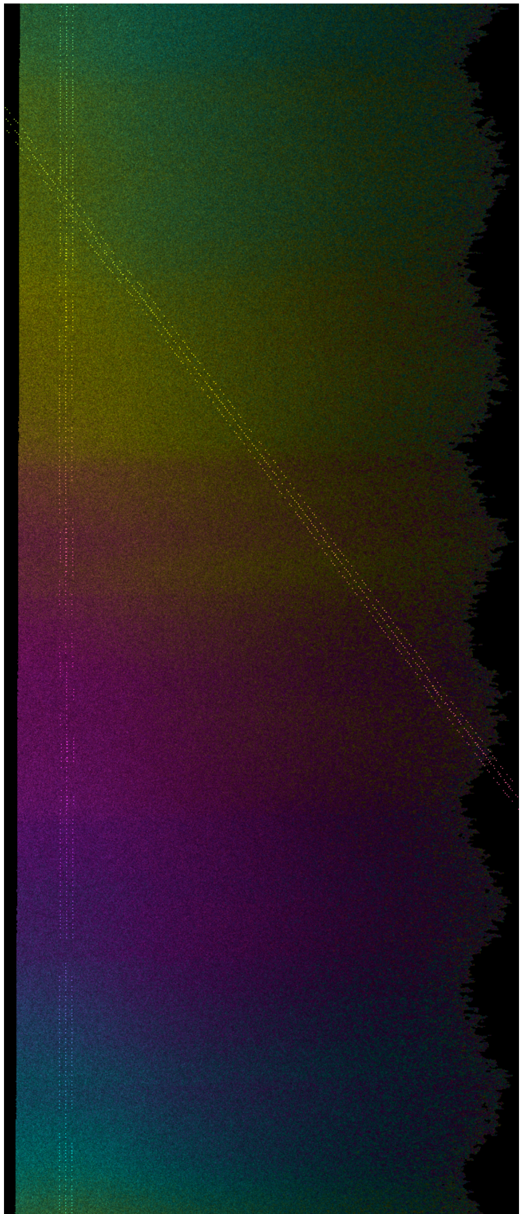


- The correspondence of frequency and magnitude of the observed multipath between antenna range measurements and data observations show good system stability for the phase-screen correction.
- Detailed processing has progressed – we generated a phase-screen correction that corrects simultaneously for the interacting multipath and residual baseline systematic artifacts

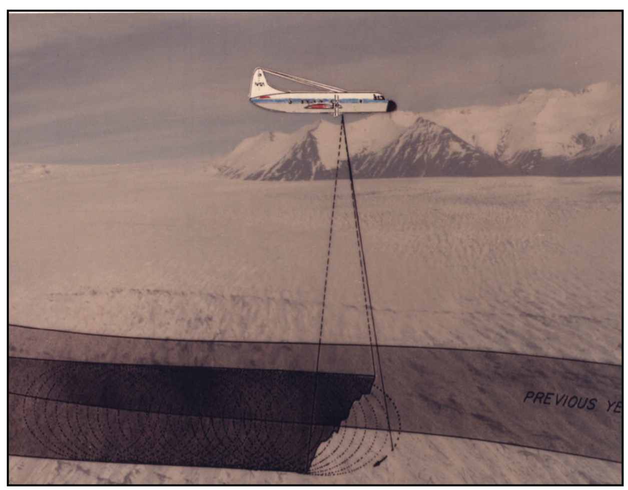
Phase Drift Observed in Long Data Line

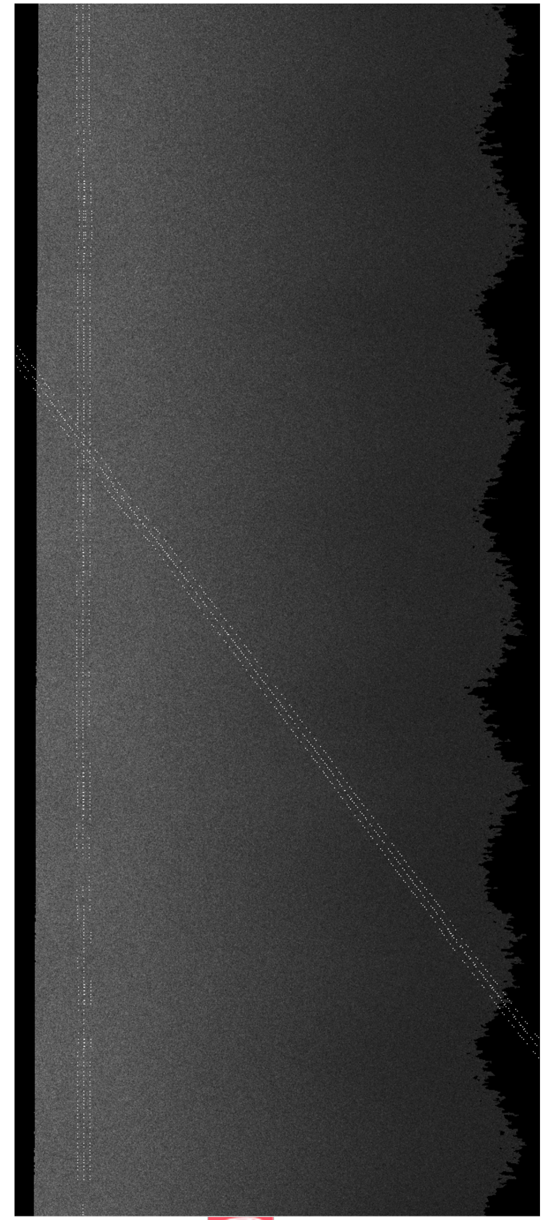


Ka-band and Lidar Data Comparison

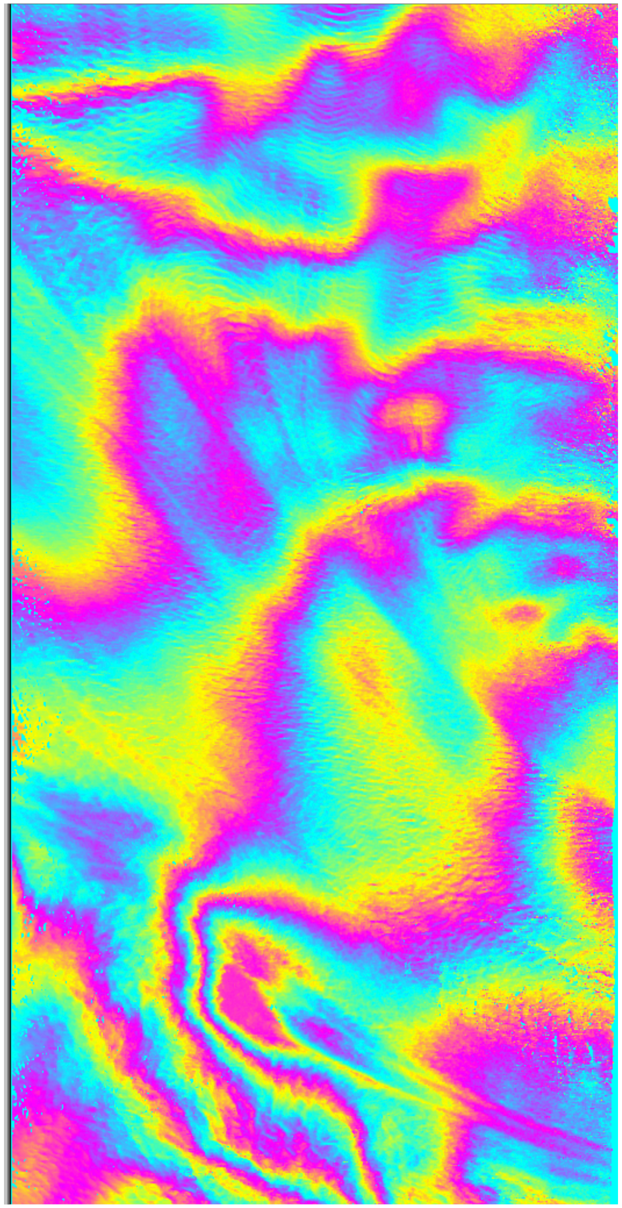


- Ka-band single pass interferometric data was collected at Greenland's Summit in Greenland along with ATM lidar data.
- Lidar tracks are shown overlaid on two passes of Ka-band elevation. Approximately 10,000 lidar points are contained in each scene.
- Initial observations show mean difference of 34cm (σ~1m). Further refinement and additional observations will better bound this/
- Predicted penetration is in the range of 10-30 cm.

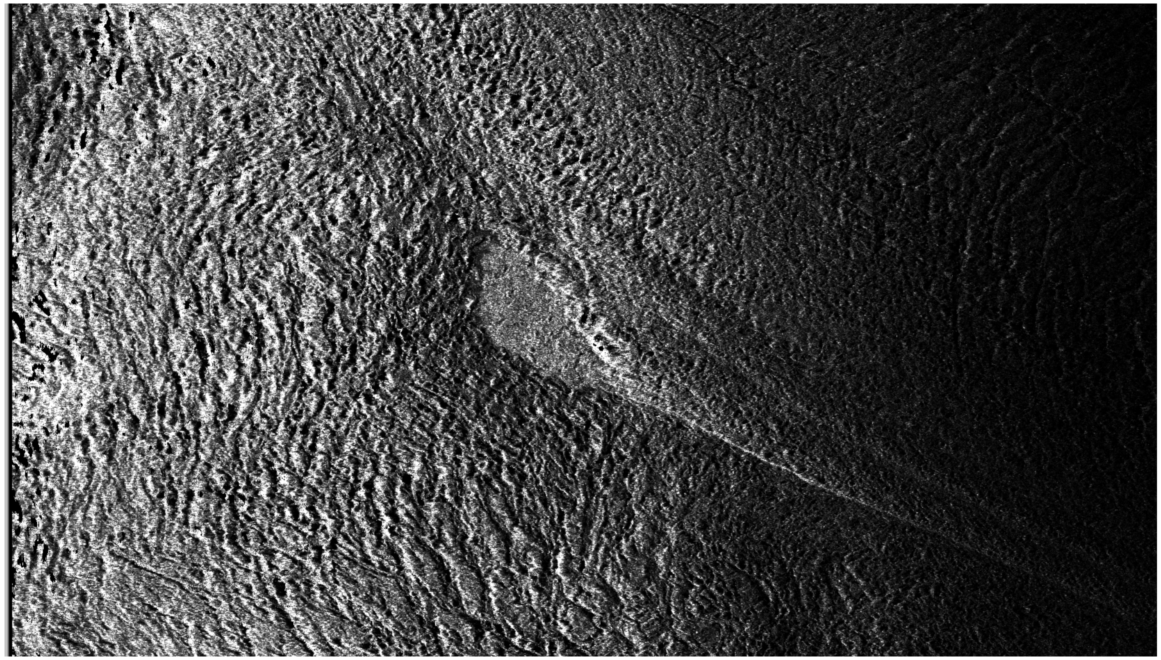


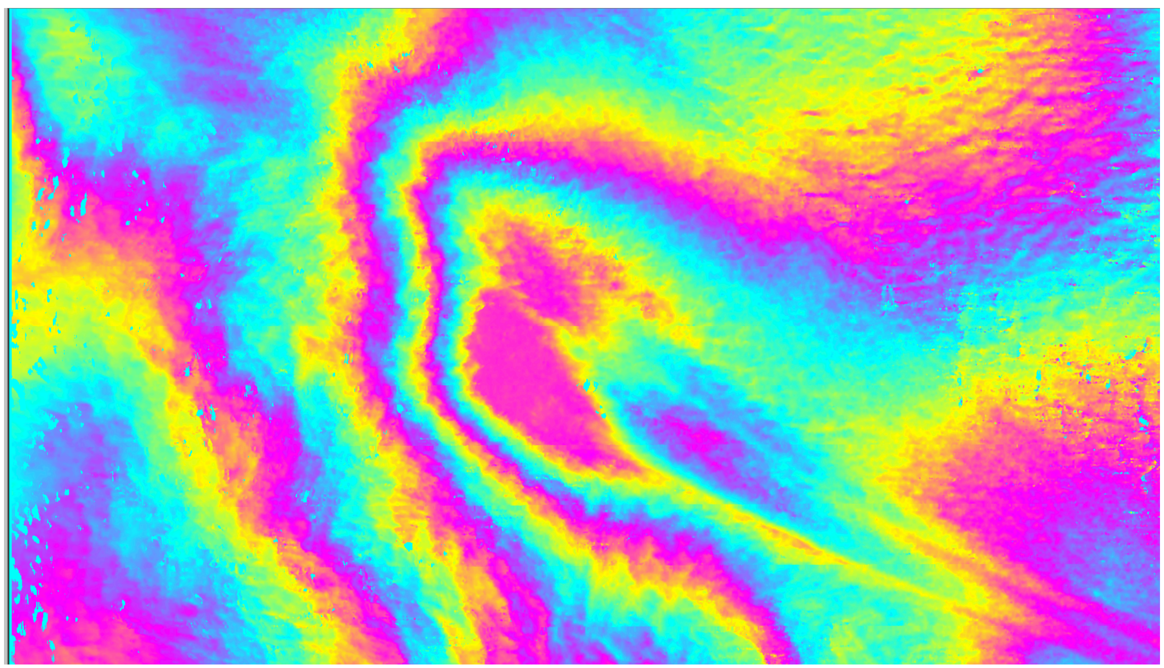


Some recent high-relief images



- 80m color wrap for height
- Images ~7km range x 12km long





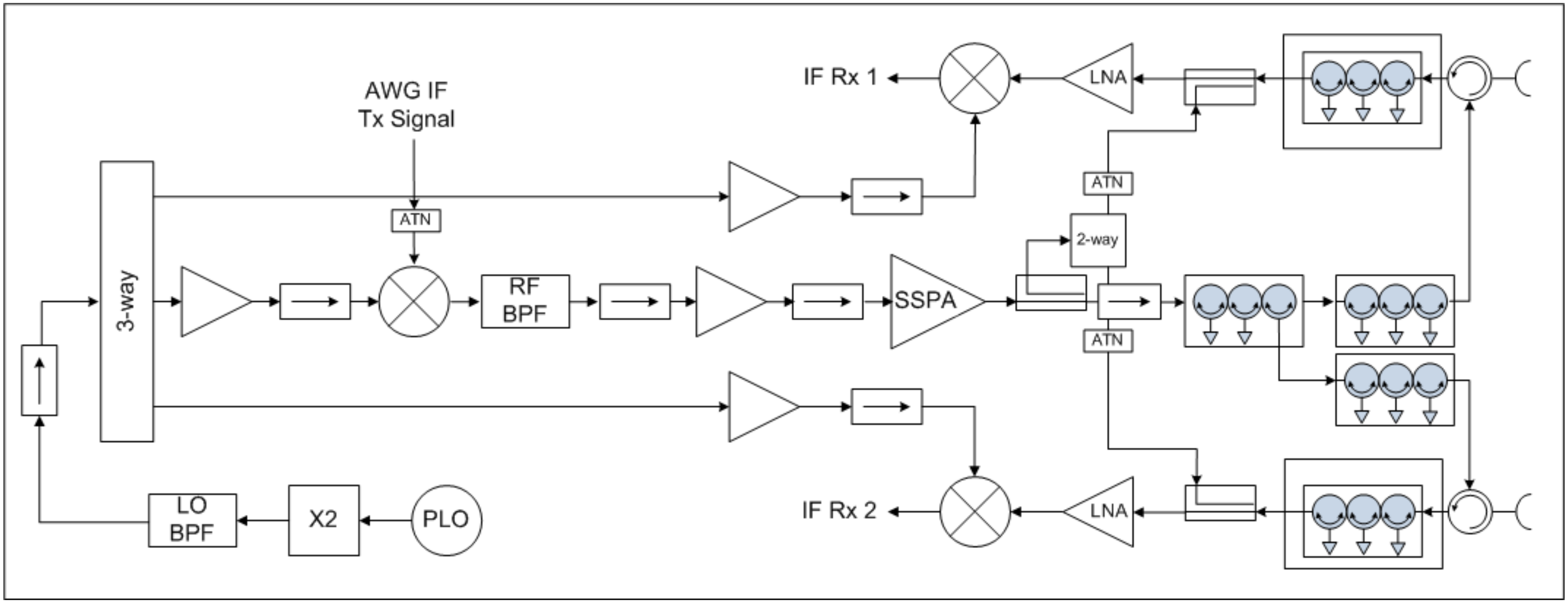
AITT GLISTIN-A Upgrades

AITT Upgrades

Parameter	Unit		IPY	GLISTIN-A
Peak transmit power (at antenna)	W		40 (TWTA)	40 (SSPA)
Receive Losses	dB		5	2
Ping-pong			No	yes
Nominal flight altitude (AGL)	km		7	11
Nominal Swath	km		6	10
Height precision (30x30m posting)	m	15^{o}	0.06	0.10
		31^{o}	0.14	0.11
		50^{o}	0.50	0.49

- New RF front-end to include ping-pong
  - Minimum 80dB isolation
  - Cal-loop integrated with UAVSAR
- SSPA for solid-state self-contained configuration
  - Transmit power equivalent but reduced receive losses

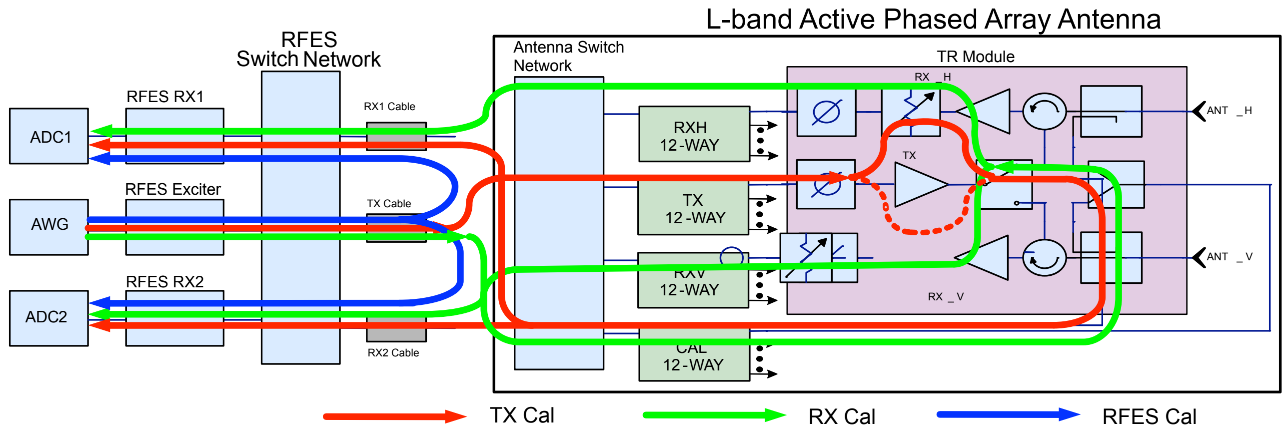
Block Diagram

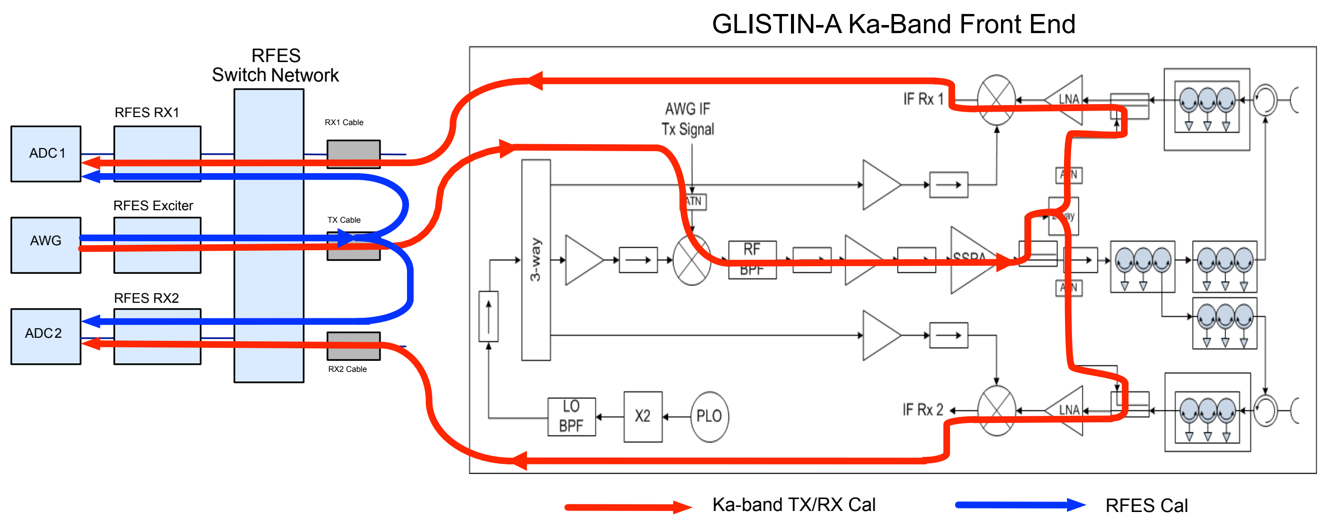


- > 80dB cross-channel isolation requirement
- Cal-loop SNR > 40dB

Calibration Loop

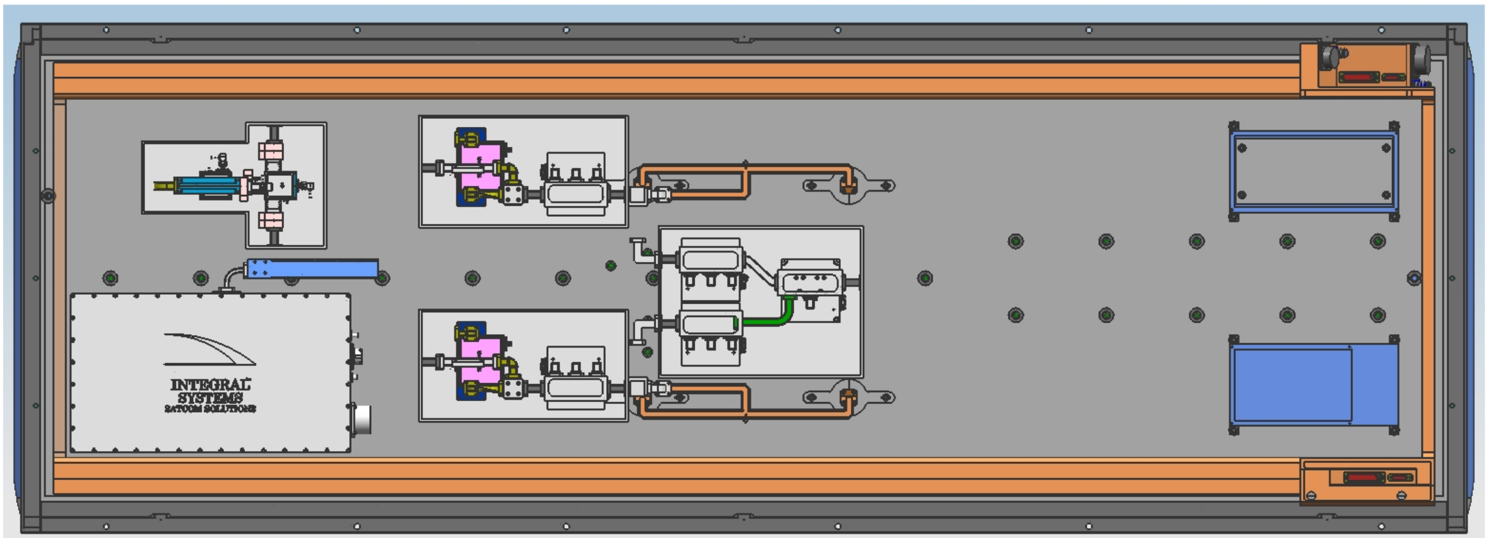
- Loopback Calibration is used to measure TX/RX gain and phase products
- Differential gain and phase of upper and lower receivers is used to remove drifts
- Calibrations are controlled and recorded in exactly the same way as during UAVSAR L-band data collections
- No hardware or software changes required



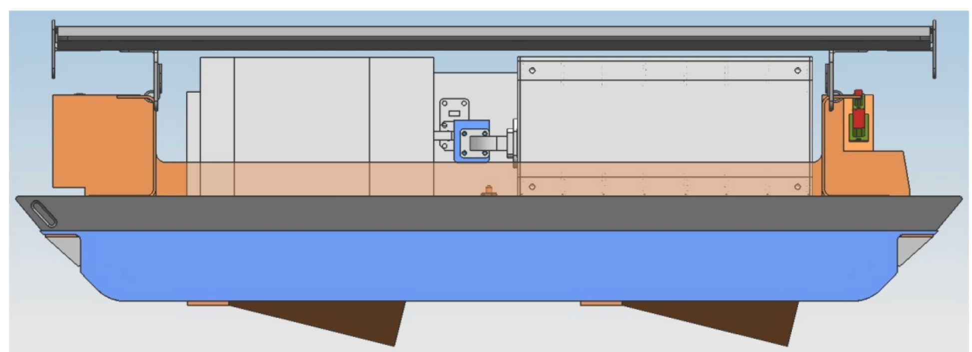


Electronics Layout

- No major modifications to the antenna panel.
  -SSPA will fit if heat can be removed from the sides instead of the top.
- GLISTIN-A antenna uses the same connector bulkheads and has the same pod mechanical interfaces as UAVSAR



- Thermal analysis verified SSPA will stay close to 25°C with natural convection only. Pod ducting will be plugged for flight operations



Implementation Timeline

- RF subassemblies nearly complete with the exception of the SSPA
- Accommodation and initial layout complete
- Preliminary thermal analysis complete, detailed underway for thermal control and electronics packaging design
- System I&T late this calendar year
- GIII install and engineering checkout Spring 2012 but interdependent with UAVSAR resource availability

GLISTIN-A Technology Heritage and Infusion

HiWRAP: IIP & NASA SBIR

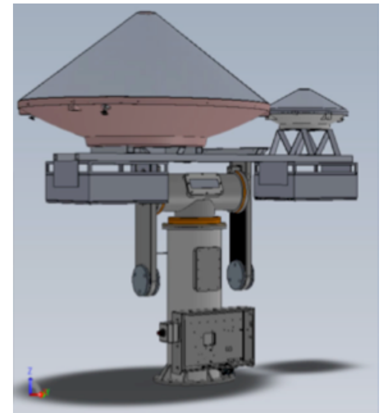
Multichannel, high-throughput digital system compatible with unpressurized unattended operation

GLISTIN-A: IPY & AITT

First demonstration of mm-wave SAR interferometry

- *technology development & technique demonstration*
- *Processor development is direct heritage for KaSPAR/ AirSWOT*

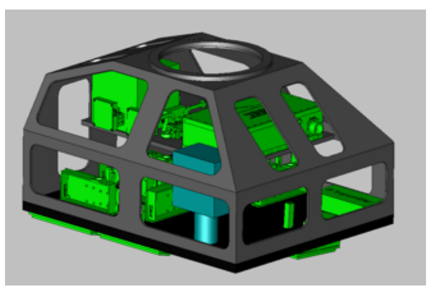
D3R GPM cal/val sensor: SBIR

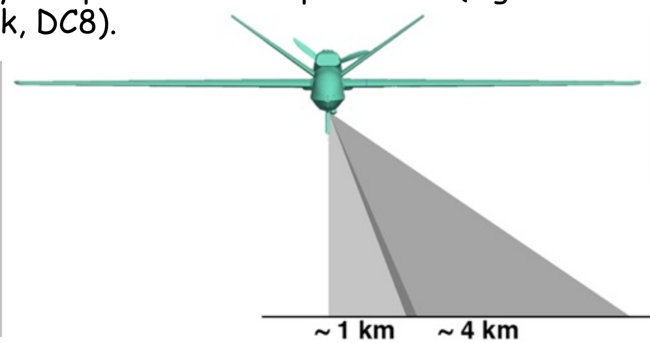


High power Ka-band solid-state power amplifier will be utilized for GLISTIN-A and AirSWOT

AirSWOT SWOT cal/val sensor: ESTO & NASA SBIR

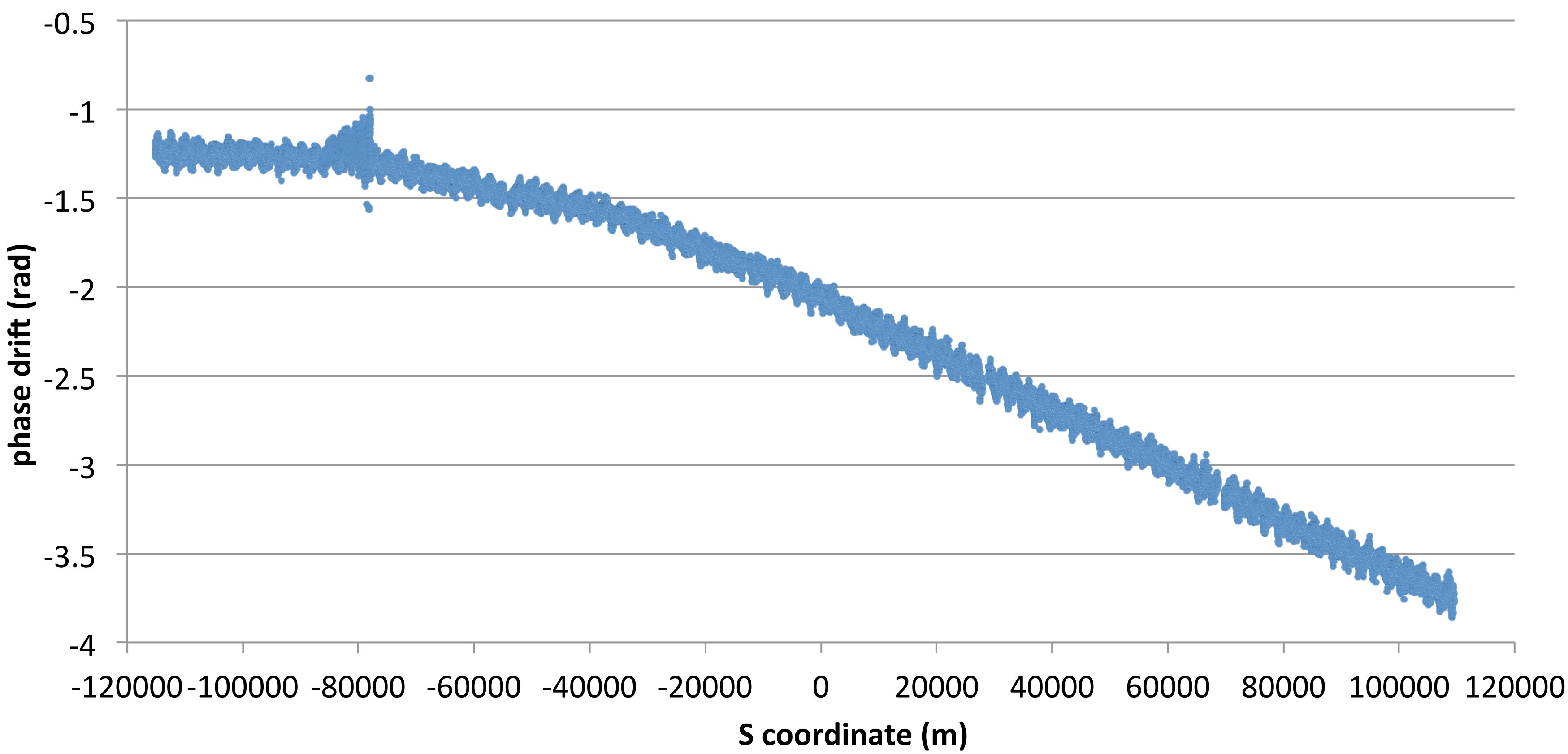
Compact integrated assembly compatible across platforms (e.g. NASA King Air, Ikhana, Global Hawk, DC8).





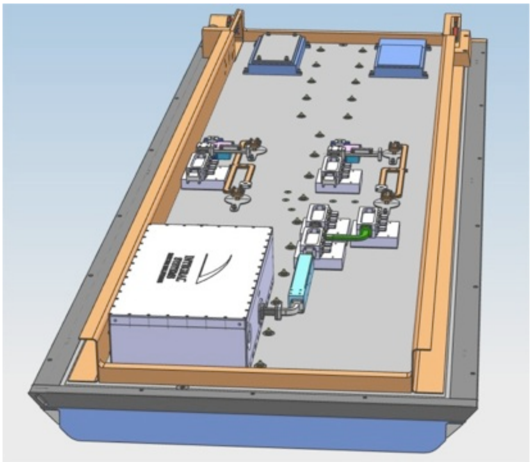
Backups

Phase drift as a function of along track estimated from comparison with ATM height

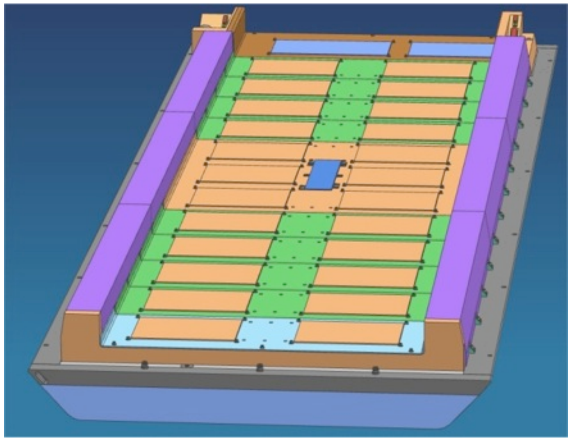


Globalhawk Considerations

- GLISTIN-A will be interchangeable with UAVSAR w/ no mods to UAVSAR or GH.
  - Mass and CG
    - Mass of GLISTIN-A antenna will be considerably less than UAVSAR.
    - Account for difference either by ballast on antenna or ballast on GH.
    - CG on antenna can be matched by adding ballast on the antenna.
- GLISTIN-A already meets same environment requirements for temperature, vibration, load factors, etc. as UAVSAR.
- Flight altitudes of GLISTIN-A compatible with GH
  - Includes RF Breakdown analysis



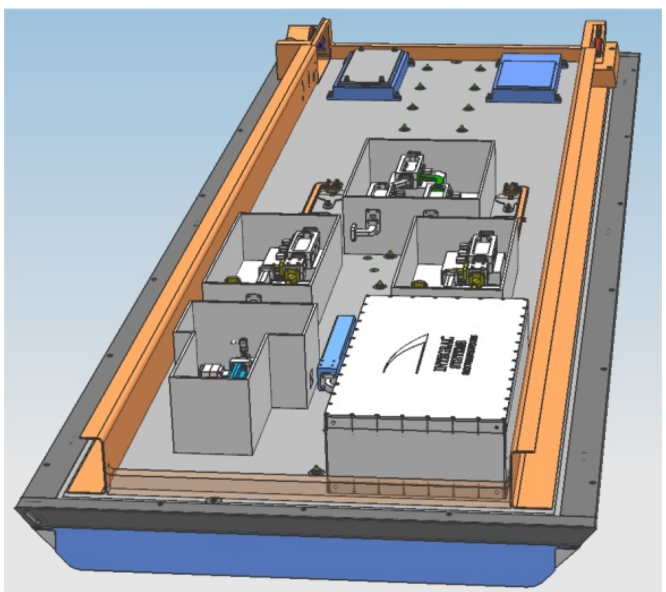
GLISTIN-A



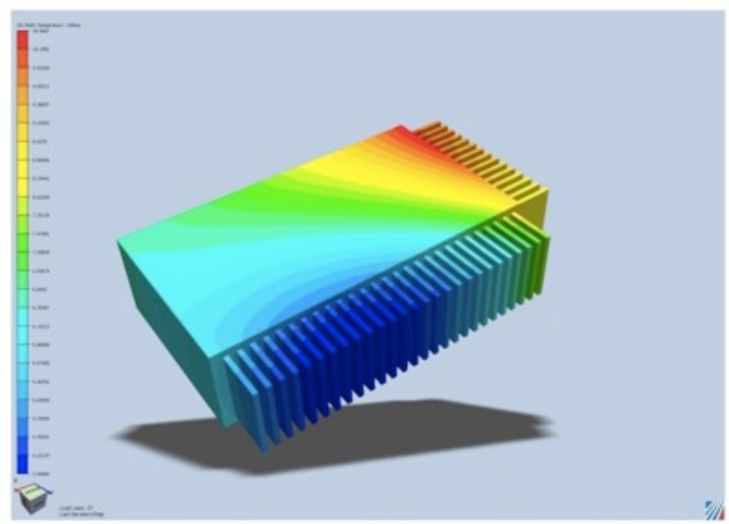
UAVSAR

Pod Accommodation and Interfaces

- GLISTIN-A antenna will use the same connector bulkheads design as UAVSAR.
- Mechanical interface to pod remains the same, as does radome interface.
- No modifications to the pod are needed.
- Thermal analysis verified SSPA will stay close to 25°C with natural convection only. Pod ducting will be plugged for flight operations.
  - UAVSAR AC unit will be used for cooling during ground tests
- Survival heaters used to maintain operating temp on all electronics.

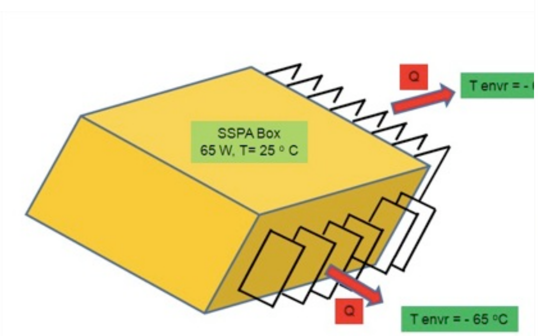


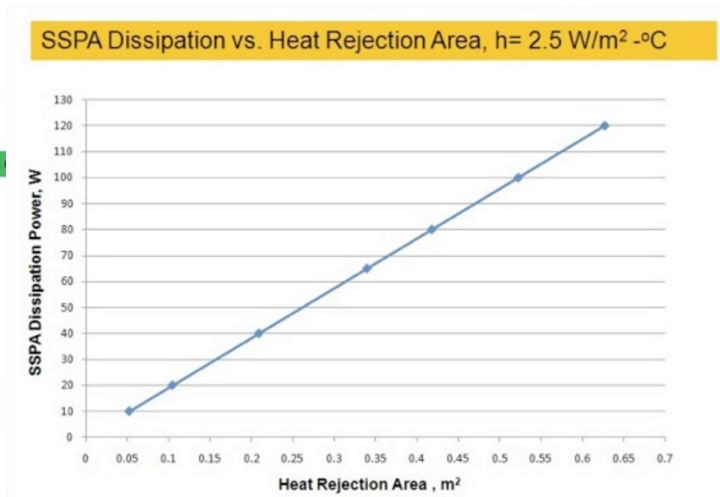
CFD Analysis-SSPA Box Temperatures for $h = 2.5\ W/m^2\text{-}^{o}C$



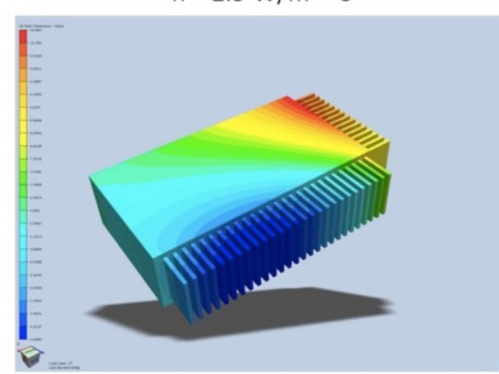
SSPA Cooling/Thermal Analysis

- SSPA creates the majority of heat for the entire system conservatively estimated at ~65 W.
  - Assumes 5% duty cycle, poor efficiency (8%) and 40W non-transmit power draw
- Thermal analysis verified SSPA will stay close to 25°C with natural convection only. Pod ducting will be plugged for flight operations.
  - UAVSAR AC unit will be used for cooling during ground tests
- Analysis is conservative but will be refined; design can accommodate changes to improve cooling.
- Survival heaters used to maintain operating temp on all electronics.



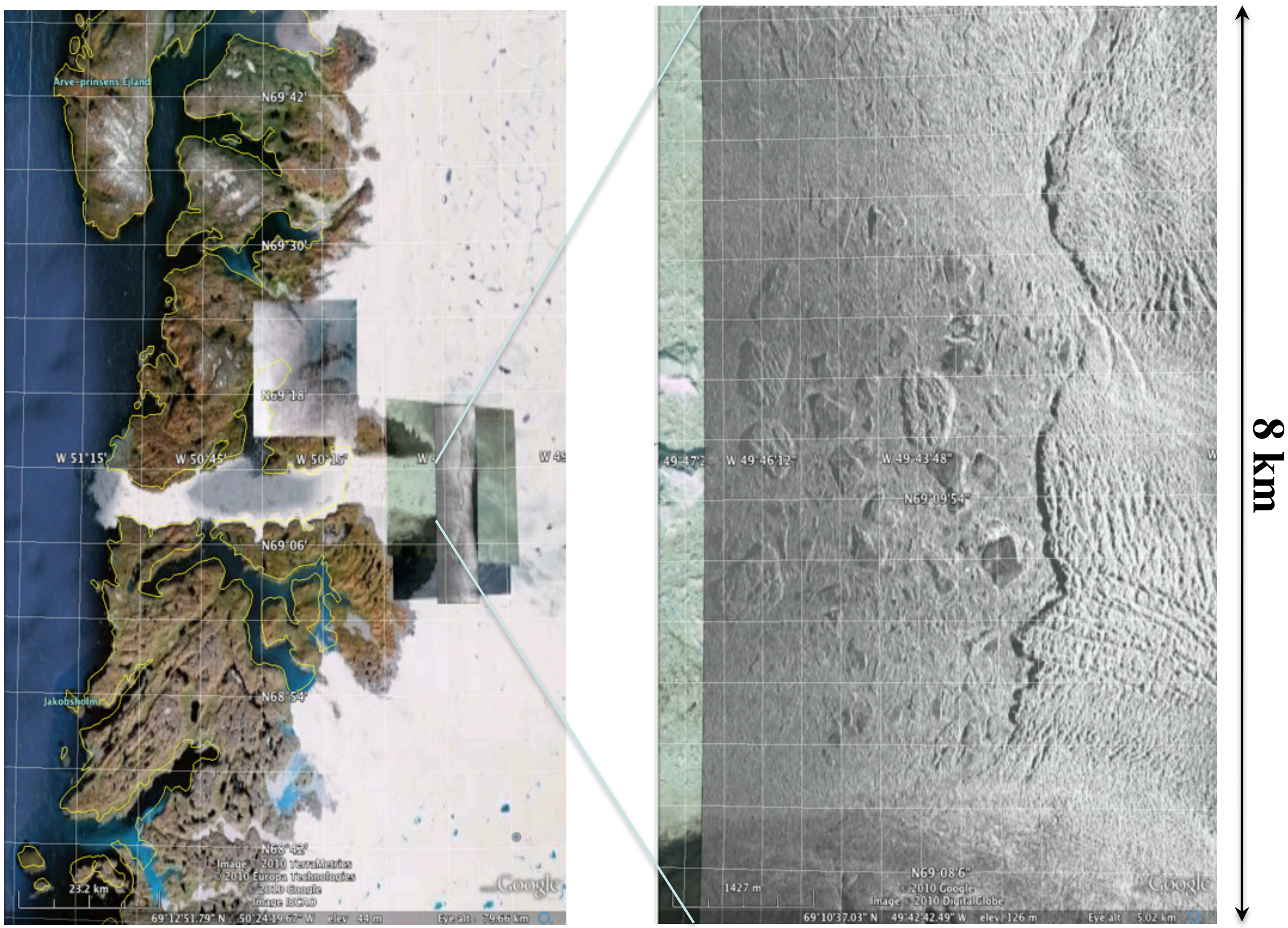


CFD Analysis-SSPA Box Temperatures for h = 2.5 W/m²-°C



Jacobshavn Glacier Ka-band Imagery

Quick Look Intensity Processing: May 6 and May 12 – Jakobsholm Pass



- Left shows Google Earth view zoomed out to show surrounding region. Quick look processing image is also shown in Google Earth.
- Right images are zoomed in to shown more details in the quick look processing (intensity only) of Jakobsholm pass. They have been imported into Google Earth.
- From the 6th to the 12th (toggle between) the ice sheet retreats ~ 1 km.

IPY Observations: System Stability

The correspondence of frequency and magnitude of the observed multipath between antenna range measurements and data observations suggests good system stability for the phase-screen correction.
Below shows the multipath from several data takes over different days after correcting for a drift term